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INVESTIGATION OF COMPONENT SEGREGATION IN WETTED GLASS BATCH

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Model systems are used to study the behavior of the powdered components in glass batch with periodic mechanical stimulation of the batch storage bin. In the two-component system quartz-sand – soda segregation increases the content of soda particles in the upper layers of the batch and the content of sand particles in the lower layers. This separation is reduced by wetting the powdered mixture. Investigation of the segregation of different fractions of the powdered dolomite established that wetting also weakens the segregation of different fractions of powdered dolomite.

Key words: glass batch, segregation, wetting of powder, capillary consolidation of particles.

An important stage of glass production is the preparation of the glass batch [1]. The admissible deviations from the prescribed content of the components in batch are regulated for each type of glass separately. The batch composition must be constant in individual weigh-ins and in time. The quality of the molten glass depends on the accuracy and care taken in the preparation and initial mixing of the starting materials. Breakdown of batch uniformity gives rise to flaws in the glass, as a result of which rejects and cullet increase and the output of ready product decreases. Batch preparation involves the following operations: weighing and batching the components, mixing and wetting the mixture. The batch must be wetted in order to increase the reactivity of the quartz grains and the binding between particles of different materials as well as to prevent layering and dust generation. The moisture content of batch is standardized at 2 – 4% depending on the type of glass produced. Overconditioning and clumping are not allowed. The experimental procedure and the first results of an analysis of the segregation processes occurring in dry mixes of the raw components are published in [2].

SEGREGATION IN THE SYSTEM QUARTZ-SAND – SODA – WATER

Mechanical stimulation of dry batch promotes redistribution of the particles: sand as the heavier material moves downward, displacing soda in the upper layers. Wetting consolidates individual components of the batch into conglomerates. As a rule the wetting liquid is incapable of dissolving all of the soda. The objective of the present work is to analyze the behavior of the two-component system quartz-sand – soda with a small amount of liquid added, which reflects the actual technological processes.

The redistribution of the components over five layers of batch was studied. The following initial mass ratios of the components sand/soda were used (%): 30/70 (composition 1), 20/80 (composition 2) and 10/90 (composition 3). A uniform mixture was wetted with water (1 and 4%) and shaken 35, 70, 100 and 300 times. Next, the composition was divided into five layers. The change in density of the two-component batch over height is shown in the figures presented below (the top and bottom layers of the mixture of components are designated by 1 and – 5, respectively).

When the batch is wetted with water (4%) and the mechanical stimulation is are small the formation of individual conglomerates can be observed visually. In consequence, the bulk density remains approximately constant from the first to the fourth layer (Fig. 1).

Prolonged mechanical stimulation causes the conglomerates comprised of sand particles bonded by streaks of water to break down, the bulk density gradually increasing from the top to bottom layer. The bulk density of the mixture in the bottom layers is higher than that of sand. This is due to the fact that the soda particles penetrate into the pores in the sand. At the same time the mass per unit volume increases and therefore the bulk density also increases.

Curing the quartz-sand – soda mixture with water gives a more uniform distribution of the components with the same

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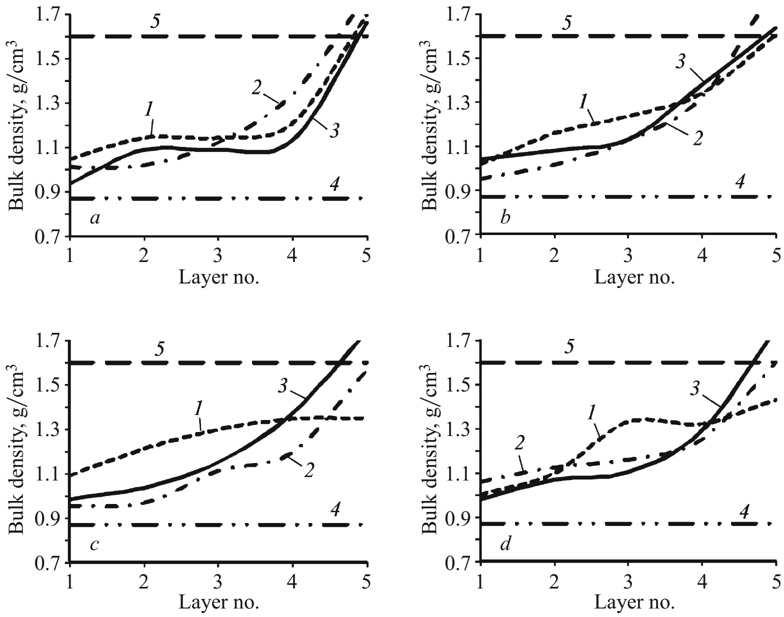

Fig. 1. Bulk density in the soda – sand system (moisture content 4%) at different levels after mechanical stimulation of uniform batch (number of shakes): *a*) 35; *b*) 70; *c*) 100; *d*) 300; *1* – *3*) compositions 1 – 3, respectively; *4*) soda; *5*) sand.

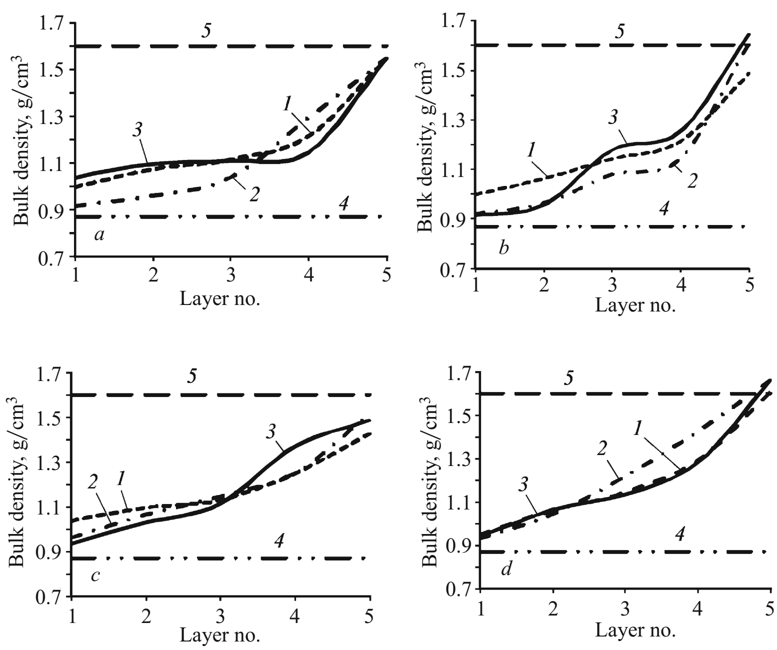

Fig. 2. Bulk density in the soda – sand system (moisture content 4% and curing time 40 min) at different levels after mechanical shaking of a uniform batch (number of shakes): *a*) 35; *b*) 70; *c*) 100; *d*) 300; *1* – *3*) compositions 1 – 3, respectively; *4*) soda; *5*) sand.

number of shakes (Fig. 2). This is because capillary-crystallization bonding of the remaining conglomerates occurs during the curing process. The particulars of such bonding have been studied in [3, 4]. Small mechanical stimulation produces a more proportionate change in the bulk density of the mixture.

SEGREGATION OF DIFFERENT FRACTIONS OF WETTED DOLOMITE POWDER

Water wetting. To study the separation of the dolomite powder fractions the dolomite was first crushed and ground. The result was the following ratio of the dolomite powder fractions (wt.%): 1 – 2 mm — 52.9%; 0.5 – 1 mm — 7.4%; and, < 0.5 mm — 39.7%. The segregation of different fractions of dolomite powder wetted with water was studied first. The moisture content of the experimental powder was 1, 2, 3 and 4%. The well-mixed starting powder containing particles of different size was shaken 100 times in each case. Graphical plots of different fractions of the material over layers of the batch versus the moisture content were constructed (Fig. 3).

The initial content of different fractions is presented in the form of straight lines in these and subsequent figures.

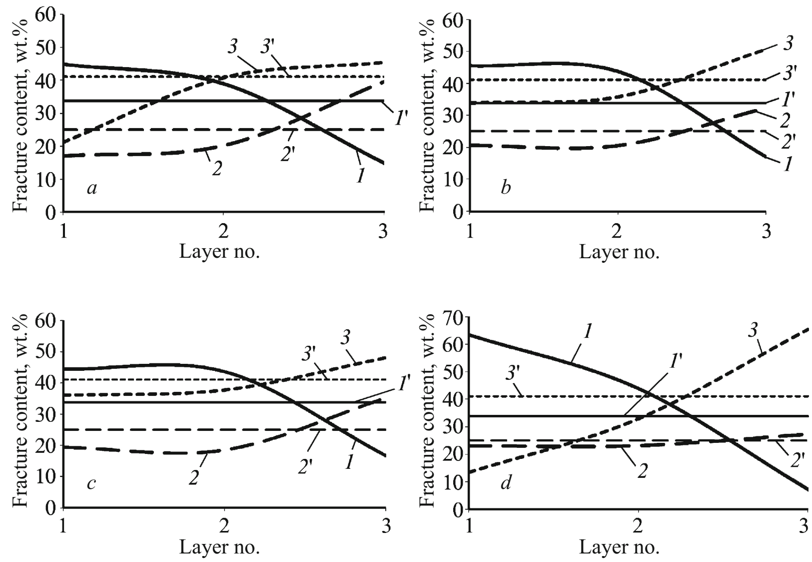

Fig. 3. Distribution of the fractions of water-wetted dolomite powder over layers of the batch (moisture content): *a*) 1%; *b*) 2%; *c*) 3%; *d*) 4%; dolomite fraction: 2 – 1 mm (*1*, *1′*); 1 – 0.5 mm (*2*, *2′*); 0.5 mm (*3*, *3′*) in the initial composition (*1′*, *2′*, *3′*) and after mechanical stimulation (*1*, *2*, *3*).

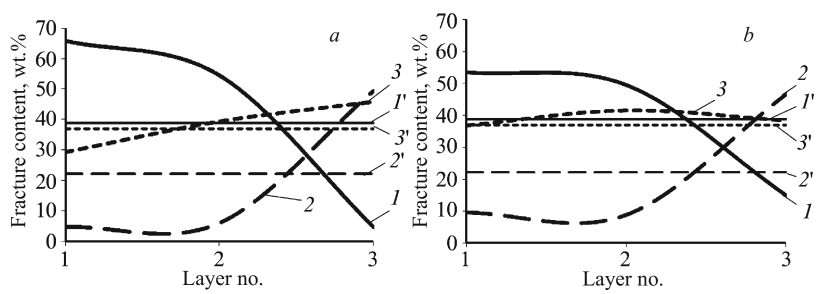

Fig. 4. Distribution of the fractions of the soda-wetted dolomite powder (moisture content 1%) over the layers of the batch: *a*) no curing period; *b*) 40 min curing period; see Fig. 3 for the labeling.

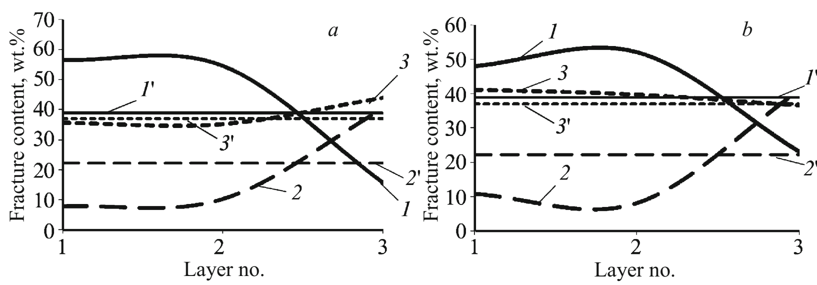

Fig. 5. Distribution of the fractions of the soda-wetted dolomite powder (moisture content 4%) over the layers of the batch: *a*) no curing period; *b*) 40-min curing period; see Fig. 3 for the labeling.

The dependences obtained show that the distribution of the fractions over levels changes considerably going from dry to wet material. The distribution becomes more nonuniform: the amount of the coarse fraction decreases at the bottom level and the amount of the fine and medium fractions increases. In addition, for a small amount of moisture (*a* – *c*) the changes are negligible, while for moisture content 4% (*d*) greater re-distribution occurs. It is known that capillary attraction between solid particles is directly proportional to the particle size. Evidently, in the presence of moisture the coarse fraction starts to behave independently of the other fractions. The capillary interaction of the large particles leads to consolidation of the particles and promotes a transition into the upper level along the height of the batch column. The fine fraction moves downward; the capillary force is too weak to restrain the particles.

Soda wetting of dolomite powder. For subsequent experiments the dolomite powder was wetted by a soda solution with concentration 1 mole/liter. In all cases 100 shakes were applied. The moisture content of the experimental batch was 1 and 4%. The experiments with wetted batch were performed immediately after wetting and also with a 40-min curing period. Plots of the distribution of the different fractions of the material over layers in the batch versus the preparation of the materials and the moisture content are presented in Figs. 4 and 5. For 1% wetting of the dolomite powder the amount of the fine fraction does not change much

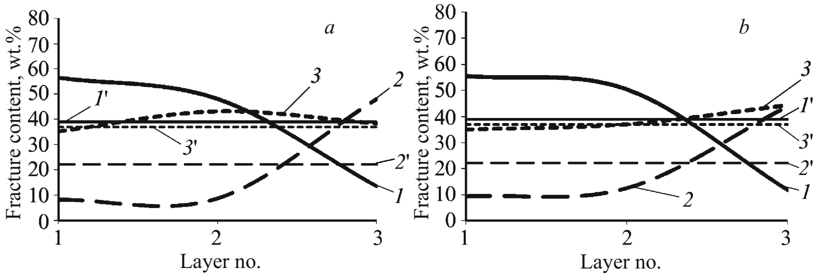

Fig. 6. Distribution of the fractions of the potash-wetted dolomite powder (moisture content 1%) over the layers of the batch: *a*) no curing period; *b*) curing period 40 min; see Fig. 3 for the labeling.

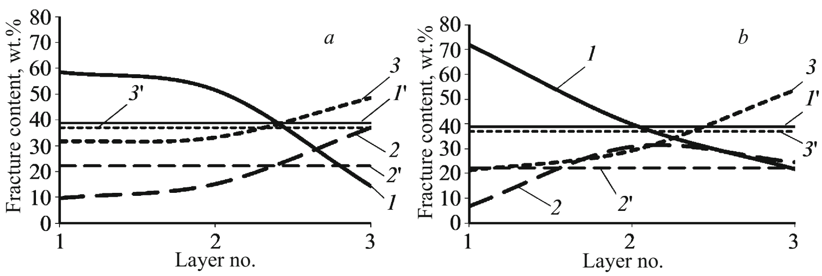

Fig. 7. Distribution of the fractions of the potash-wetted dolomite powder (moisture content 4%) over the layers of the batch: *a*) no curing period; *b*) 40-min curing period; see Fig. 3 for the labeling.

from the top to bottom levels; this is especially obvious in experiments performed with a 40-min curing period.

For 4% wetting of the dolomite powder with no curing period the content of the coarse fraction increases somewhat toward the first level and decreases in the last two levels. In this case the medium fraction shows the opposite behavior. The amount of the fine fraction increases very little toward the bottom level. With a 40-min curing period the content of the coarse fraction increases from the first to second layer and then decreases sharply. Conversely, the amount of the medium fraction decreases at first and then increases. The content of the fine fraction remains practically unchanged.

Postash wetting of dolomite powder. Plots of the experimental results were constructed.

For 1% wetting of dolomite powder with a solution of potash (Fig. 6) and no curing period the content of the coarse fraction is 55% in the first layer and decreases sharply in the last two layers. The opposite results were obtained for the content of the medium fraction. The amount of the fine fraction remains practically unchanged. The situation with all fractions with a 40-min curing period is practically identical to the preceding case.

In the experiments with no curing period and 4% wetting of the dolomite powder (Fig. 7) the content of the coarse fraction remains unchanged initially and then decreases sharply. The amount of the medium and fine fractions changes identically and oppositely compared with the coarse fraction. The curves change after a 40-min curing period. The amount of the coarse fraction is greatest at the first level and then decreases sharply. The amount of the fine fraction increases.

CONCLUSIONS

Wetting quartz sand – soda mixtures fixes the initial distribution all the more firmly the better the conditions for the formation of conglomerates of the starting particles bonded by capillary forces as well as by capillary-crystallization contacts are satisfied. Water wetting of the dolomite powder changes the redistribution of the particles after shaking. For wetting of the dolomite powder by salt solutions the crystals appearing after the water has evaporated decrease the mobility of the powder particles, which impedes segregation.

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